

REMARKS

The Office Action states that a new oath or declaration is required since the title of the invention is spelled incorrectly on the declaration. Applicant's respectfully disagree with the Examiner. Although the title "Power Circuit-Breaker" appears on the cover sheet of the PCT application, the English translation of the German priority application and of the instant application is appropriately titled "Protective Switching Device." In any event, the oath/declaration is only required to identify the application, which is properly done by identification of the PCT and German application numbers.

The drawings have been objected to as failing to identify the reference "M" in the specification. The drawings have been amended to remove reference "M."

The Office Action is requiring a substitute specification. Amendments to the specification, consistent with the Preliminary Amendment previously filed, have been made and are submitted herewith in the attached Substitute Specification. A clean copy of the specification and a marked-up version showing the changes made are attached herewith. No new matter has been added.

The disclosure has been objected to as due to informalities. The specification has been amended to conform with the Examiner's suggestions. However, Applicants were unable to determine where in the specification the remote tripping signal S_s should be changed to S_f . The Examiner is kindly requested to verify this typographical error.

Claims 1-2 and 8 have been rejected under 35 USC 102(b) as anticipated by Paupert (EP 0367690). The rejection is respectfully traversed.

Paupert discloses an additional coil on the cumulative current converter, but not a galvanic separation of the remote trigger key for the main power circuit. In the claimed invention, on the other hand, the protection circuit device utilizes a specific transmitter, which does not measure fault current or short circuit detection between GND and the neutral conductor. Rather, the claimed invention achieves a galvanic separation of the remote trigger key and the main current circuit.

Since the recited structure is not disclosed by the applied reference, claims 1-2 and 8 are patentable.

Claims 3-5 and 9-10 have been rejected under 35 USC 103(a) as unpatentable over Paupert in view of MacKenzie (U.S. Patent No. 5,459,630). The rejection is respectfully traversed for the reasons set forth in the arguments above, and for the following reasons.

The Examiner states that Paupert fails to disclose “the use of an oscillator, comparator, and a transistor switch as part of the protection switch,” but that MacKenzie discloses same. In MacKenzie, the second converter, which exists, is used simultaneously to detect a short circuit between GND and the neutral conductor and for remote actuation. Hence, with respect to remote actuation, a voltage separation between the remote trigger and the main current circuit is possible. The second converter is not used for remote triggering in most cases. Rather, the converter becomes inoperable if a line length of several hundred metres between the protective circuit device and the remote trigger switch is specified. This is so since the line resistances and capacities are important, and the second converter is designed so that a short circuit between the GND and neutral conductor can be detected.

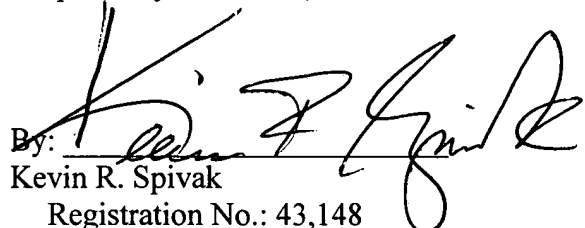
Since the recited structure is not disclosed by the applied references (either alone or in combination), claims 3-5 and 9-10 are patentable.

Claims 6-7 would be allowable if rewritten in independent form to include any base and intervening claims.

In the event the U.S. Patent and Trademark Office determines that an extension and/or other relief is required, applicant petitions for any required relief including extensions of time and authorizes the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to Deposit Account No. 03-1952 referencing docket no. 449122000900. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

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MARKED-UP SPECIFICATION

Description

PROTECTIVE SWITCHING DEVICE

CLAIM FOR PRIORITY

This application claims priority to International Application No. PCT/DE99/01074 which was published in the German language on October 28, 1999.

TECHNICAL FIELD OF THE INVENTION

The invention relates to a protective switching device, and in particular to a differential-current circuit breaker, having a core-balance transformer which monitors a line network and which, via a tripping circuit and an actuation circuit, actuates a release which is coupled to a switching mechanism in order to operate a power breaker.

BACKGROUND OF THE INVENTION

Such a protective switching device is described in (US-A4 001 646). The protective switching device is used to ensure protection against a dangerous body current in an electrical system. ~~This is the case, for~~ For example, when someone touches a live part of an electrical system. ~~The, the~~ the fault current then flows via the person as a body current to ground. The circuit breaker which is used for protection against dangerous body currents safely and rapidly isolates the relevant circuits from the mains power supply when the so-called rated fault current is exceeded.

The construction of a circuit breaker is ~~known~~described, for example, from "etz", Volume 107 (1986), issue 20, pages 938 to 945. There, Figures 1 to 3 in particular show basic circuit diagrams and functional principles of a fault-current circuit breaker (FI circuit breaker) and a differential-current circuit breaker (DI circuit breaker).

FI and DI circuit breakers are constructed in a similar way from three assemblies. A core-balance transformer, through whose transformer core all the current-carrying conductors of a line network are passed induces a voltage signal in its secondary winding in the event of a fault current, and this voltage signal actuates a release which is connected to the secondary winding. For its part, the release is coupled to a switching mechanism via which, when the release is operated, the contacts of a power breaker connected in that line or in each line are opened. In the process, the FI circuit breaker draws the energy required for tripping from the fault current itself, irrespective of the mains power supply voltage, while tripping in the case of a DI circuit breaker takes place as a function of the mains power supply voltage. To this end, when a fault current occurs in the electrical circuit supplied from the line network, the signal emitted from the core-balance transformer is supplied, after amplification by means of an electronics unit that is dependent on auxiliary energy, to the DI tripping circuit of the DI circuit breaker or DI accessory.

A test device having a test button is provided for checking the serviceability of such a protective switching device for circuit breaker, which test button is normally connected between the neutral conductor (N) and a phase conductor (~~L1~~L1, L2, L3) of the line network. When the test button is pressed, a fault current is

simulated, and the reaction of the circuit breaker is tested. In this case, the circuit breaker must trip with virtually no delay when in the serviceable state.

Furthermore, a remote release is frequently provided in such circuit breakers, via which - for example for disconnection - the circuit breaker and thus the power breaker coupled to it can be operated externally._ In order to provide a remote release for a DI circuit breaker, one option is for a ~~make~~mate contact to be connected in parallel with the test contact via a remote tripping line connected to said DI circuit breaker._ Another option is for a separate winding to be provided in addition to the test winding on the core-balance transformer,~~which~~. The separate winding is connected between two external conductors or between one phase conductor and the neutral conductor via a current limiting resistor, for operation of a remote tripping switch._ These two versions for remote tripping on the one hand also require at least one ~~auxiliary~~auxiliary contact, however, in a disadvantageous manner._ On the other hand, the feeders to the remote tripping switch and the switch contact for the remote release must be designed for a particularly high withstand voltage.

In the case of a DI accessory for power breakers, an additional exacerbating factor is that no auxiliary contacts can be provided owing to the switching paths accommodated in the power breaker. Since such circuit breakers are also designed with three poles, a connection between two ~~external~~outer conductors would also be required. Furthermore, a particular feature of DI circuit breakers or accessories is that tripping time delays of up to one second can frequently be set. Thus, if the remote release were operated according to the said ~~variants~~variance, a relatively long tripping time would have to be taken into account - depending on the time

~~The tripping circuit expediently also has an oscillator in~~ In yet another aspect of the form of invention, the oscillator is a square-wave generator, which acts on the primary winding of the transformer. In order to keep the current drawn by the square-wave generator or oscillator as low as possible in this case, the whose frequency, on the one hand, is chosen to be as high as possible since the inductive impedance of the primary winding of the transformer increases in proportion to the frequency. Since, on the other hand, the remote tripping line which is connected to the transformer has an impedance which becomes increasingly low as the frequency increases owing to the parasitic capacitance between the conductor cores, the frequency is expediently set to between 500 Hz and 5 kHz. These frequency levels are optimized to an assumed primary inductance of the transformer of not less than 1 Henry, and to a cable length between the transformer and a remote tripping switch of not more than 300 m. Hz.

~~In one expedient refinement, still another aspect of the invention, the protective switching device wherein the tripping circuit has a comparator which is connected on the primary side to the transformer and is connected on the output side to the actuation circuit~~ effor the release. It is thus possible to set a response threshold for the release for remote tripping by comparing the signal on the primary side of the transformer with a reference signal in order to produce an appropriate actuation signal.

~~In order to limit the current flow through the primary winding of the transformer when a secondary winding is short-circuited, a non-reactive resistor is connected downstream~~ In another aspect of the invention, the protective switching device wherein the

tripping circuit has a non-reactive resistor $R_S > 10 \text{ k}\Omega$ which is connected to the primary winding of the transformer.

In another aspect of the ~~comparator within the tripping circuit on the primary side of the transformer.~~ This is particularly advantageous if the power supply for invention, the tripping circuit is live after remote tripping. A resistor of not less than 10 kil is particularly expedient with regard to has a minimum current draw.

In one advantageous refinement, the reference signal source provided to produce the reference signal within the tripping circuit ~~hashaving~~ a reference voltage divider which is connected in series with a zener diode ~~to~~ fed from a supply voltage. This means that the reference voltage is zero for as long as the rising operating voltage remains below the response voltage of the zener diode when the supply voltage is connected. As a result, via a zener diode.

In yet another aspect of the invention, a secondary of the transformer is connected to ground potential via a resistor series circuit.

In still another aspect of the invention, the actuation circuit comprises a comparator with a downstream controllable electronic switch, which is connected to the release.

In yet another aspect of the ~~supply voltage being switched off~~ invention, the reference voltage falls to zero when the falling operating voltage becomes less than the response voltage of the zener diode. This effectively prevents spurious tripping caused by

~~remote tripping electronics when the voltage supply is being switched on and off.~~

~~In order to prevent an electrostatic charge on the line which is connected to the transformer for remote tripping, the secondary of the transformer is expediently connected to ground potential via a series of circuits comprising at least two non-reactive resistors.~~

~~The actuation circuit preferably has a comparator which is connected on the output side via a controllable electronic switch to the release. The electronic switch is expediently a transistor, whose base control input is connected to the comparator and in whose collector-emitter circuit the a tripping relay coil of a tripping relay the release is connected.~~

~~The advantages achieved by the invention are, in particular, that remote tripping without any auxiliary contact is possible by means of a tripping circuit which acts on the release of a protective switching device connected on the secondary side of a corebalance transformer and has a transformer whose primary is connected to the release. Furthermore, there is no need for any special requirements for the withstand voltage of the remote tripping line and the remote tripping switch. Since the tripping circuit acts directly via the actuation circuit on the release, there is virtually no time delay in the actuation for remote tripping of a circuit breaker with a tripping time delay, so that safe emergency disconnection is ensured by remote tripping of the circuit breaker.~~

~~An exemplary embodiment of the invention will be explained in more detail in the following text with reference to a drawing, in which:~~

~~Figure 1 shows, schematically,~~
~~circuit breaker with the design of a DI a tripping circuit for~~
~~remote tripping, and~~

BRIEF DESCRIPTION OF THE DRAWINGS

An exemplary embodiment of the invention will be explained in more detail in the following text with reference to a drawing.

Figure 1 shows the design of a DI circuit breaker with a tripping circuit for remote tripping.

Figure 2 shows the circuit design of the tripping circuit shown in Figure 1.

Mutually corresponding parts are provided with the same reference symbols in both figures.

DETAILED DESCRIPTION OF THE INVENTION

The invention discloses a protective switching device which can be tripped remotely in a simpler and more reliable manner.

The tripping circuit comprises a transformer which has a primary winding and a second winding and whose primary is connected via an actuation circuit to the release. When the transformer is actuated, circuiting its secondary winding, produces a control signal for primary side of the transformer.

The tripping circuit expediently also has an oscillator in the form of a square-wave generator, which acts on the primary winding of the transformer. In order to keep the current drawn by the square-wave generator or oscillator as low as possible in this

case, the frequency, on the one hand, is chosen to be as high as possible since the inductive impedance of the primary winding of the transformer increases in proportion to the frequency. Since, on the other hand, the remote tripping line which is connected to the transformer has an impedance which becomes increasingly low as the frequency increases owing to the parasitic capacitance between the conductor cores, the frequency is expediently set to between 500 Hz and 5 kHz. The frequency levels are optimized to the assumed primary inductance of the transformer of not less than 1 Henry, preferably by short the tripping circuit the release on the and to a cable length between the transformer and a. remote tripping switch of not more than 300 m.

In one embodiment, the tripping circuit has a comparator which is connected on the primary side to the transformer and is connected on the output side to the actuation circuit of the release. It is thus possible to set a response threshold for the release for remote tripping by comparing the signal on the primary side of the transformer with a reference signal in order to produce an appropriate actuation signal.

In order to limit the current flow through the primary winding of the transformer when a secondary winding is short-circuited, a non-reactive resistor is connected downstream of the comparator within the tripping circuit on the primary side of the transformer. This is particularly advantageous if the power supply for the tripping circuit is live after remote tripping. A resistor of not less than 10 Ω is particularly expedient with regard to a minimum current draw.

In one advantageous refinement, the reference signal source provided to produce the reference signal within the tripping

circuit has a reference voltage divider which is connected in series with a zener diode to a supply voltage. This means that the reference voltage is zero for as long as the rising operating voltage remains below the response voltage of the zener diode when the supply voltage is connected. As a result of the supply voltage being switched off, the reference voltage falls to zero when the falling operating voltage becomes less than the response voltage of the zener diode. This effectively prevents spurious tripping caused by remote tripping electronics when the voltage supply is being switched on and off.

In order to prevent an electrostatic charge on the line which is connected to the transformer for remote tripping, the secondary of the transformer is expediently connected to ground potential by a series of circuits comprising at least two non-reactive resistors.

The actuation circuit preferably has a comparator which is connected on the output side via' a controllable electronic switch to the release. The electronic switch is expediently a transistor, whose control input is connected to the comparator and in whose collector-emitter circuit the tripping relay coil of a tripping relay is connected.

The invention can achieve remote tripping without any auxiliary contact by a tripping circuit which acts on the release of a protective switching device connected on the secondary side of a corebalance transformer and has a transformer whose primary is connected to the release. Furthermore, there is no need for any special requirements for the withstand voltage of the remote tripping line and the remote tripping switch. Since the tripping circuit acts directly via the actuation circuit on the release, there is virtually no delay in the actuation for remote tripping

of a circuit breaker with a tripping time delay, so that safe emergency disconnection is ensured by remote tripping of the circuit breaker.

Figure 1 shows the basic functional design of the differential-current circuit breaker as a protective switching device having a tripping circuit 2 and having an actuation circuit 3, which is fed from this tripping circuit 2, for a release 4, as well as having a tripping circuit 5 for remote tripping. The tripping circuit 2 comprises a core-balance transformer 6, through whose primary transformer core 7 all the current-carrying lines of a single-phase or polyphase line network L_n are passed. The secondary winding 8 of the core-balance transformer 6 is connected to a comparator 13 in the actuation circuit 3 via an electronic amplifier 10 with rectification and with a tripping time delay 12 connected downstream from it.

The comparator 13 is connected on the output side to a controllable electronic switch which, ~~for its part,~~ is connected to the release 4. In the exemplary embodiment, the switch is a bipolar npn transistor 14, whose base is actuated by the comparator 13 and in whose collector-emitter circuit, which is connected to an operating voltage U_B , a tripping ~~relay~~ release coil 15 of the release 4 is connected. The release 4 is coupled to a mechanism in the form of a switching mechanism 16 which acts on a switching path, connected in each line of the line network L_n , of a power breaker 18.

When the DI circuit breaker is operating in the absence of any faults, the vectorial sum of the currents flowing in the two directions in the line network is equal to zero. However, if a fault current via ground occurs, for example as a result of an

delay setting. However, this is unacceptable with regard to emergency disconnection.

~~The invention is thus based on the object of specifying a protective switching device, in particular a DI circuit breaker, which can be tripped remotely in a simple and reliable manner while avoiding the said disadvantages.~~

SUMMARY OF THE INVENTION

~~This object is achieved according to the invention by the features of claim 1. A tripping circuit is provided for this purpose, which actuates the release when remote tripping takes place~~In one embodiment of the invention, there is a protective switching device including a corebalance transformer which monitors a line network and actuates a release which, via a tripping circuit and an actuation circuit, is coupled to a switch mechanism in order to operate a power breaker, wherein a tripping circuit, which can be tripped by a remote tripping signal, is connected to a transformer which can be actuated on the secondary side and whose primary side is connected to an actuation circuit of the release.

~~The tripping circuit comprises a transformer which has a primary winding and a secondary winding and whose primary is connected via an actuation circuit to the release. When the transformer is actuated, preferably by short-circuiting its secondary winding~~In one aspect of the invention, if the secondary of the transformer is short-circuited, the tripping circuit produces a control signal for the actuation circuit of the release.

In another aspect of the invention, the tripping circuit produces a control signal for the release on the~~comprises an oscillator which is connected to the primary side of the transformer.~~

insulation fault in a load device (not illustrated), then this interferes with the current equilibrium in the core-balance transformer 6. The transformer core 7 is magnetized in a corresponding way to the magnitude of the fault current, so that a voltage is induced in the secondary winding 8 of the core-balance transformer 6. A corresponding amplified, rectified and ~~delayed~~ a time-delay tripping signal S_{ae} is supplied to the actuation circuit 3 of the release 4. When the release 4 responds, the switching paths of the power breaker 18 are opened via the switching mechanism 16, and the damaged part of the system is ~~in~~ consequence disconnected.

The release 4 can furthermore be actuated by ~~means of~~ remote tripping. To this end, the tripping circuit 5 comprises a transformer 20 having a primary winding N1 and a secondary winding N2, via which the tripping circuit 5 can be activated by means of a remote tripping signal S_f . A square-wave oscillator 22 acts on the primary winding N1 of the transformer 20. If the secondary of the transformer 20 is short-circuited, then the voltage across the primary winding N1 of the transformer 20 collapses. This is detected by a comparator 24 connected on the primary side to the transformer 20. On exceeding a reference voltage U_{Ref} , the comparator 24 acts on the tripping circuit 2 to actuate the tripping relay coil 15 of the release 4, by the tripping circuit 5 supplying the comparator 13 of the actuation circuit 3 with an appropriate control signal S_s . In this case, this action takes place after the tripping circuit 2, and thus after the tripping time delay 12, if such a tripping time delay 12 is provided.

Figure 2 shows the design of the tripping circuit 5 for remote tripping. The transformer 20 has a voltage divider which is connected in parallel with the secondary winding N2 and is formed

by two non-reactive resistors R11 and R12 which are connected to ground ~~FE-PE~~. This prevents any electrostatic charge on the remote tripping line (not shown) which is connected from the remote release to the connections FA1 and FA2.

The remote tripping lines are connected to the secondary winding N2 of the transformer 20 via connections FA1 and FA2. The square-wave oscillator 22 which is connected to the primary winding ~~N1~~N1 is formed by a comparator V1 with the illustrated circuitry comprising the resistors R1 to R4 and the capacitor C1. The frequency f of the square-wave oscillator 22 is set by appropriate dimensioning of the time constant $\tau = R1 \times C1$.

In order to keep the current drawn by the oscillator 22, and thus by the tripping circuit 5, as low as possible taking into account the impedance ($X_c = 1/2\pi fC$), which decreases as the frequency f increases owing to the parasitic capacitance between the conductor cores of the remote tripping lines, and taking into account the inductive impedance ($X_L = 2\pi fL$) of the primary winding N1, which increases with the frequency f , the frequency f is preferably set to between 500 Hz and 5 kHz. This takes into account a primary inductance $L_p \geq 1H$ which can be achieved for a minimum physical volume of the transformer 20, and a cable length 1 between the transformer 20 and a remote tripping switch (not shown) of $1 \leq 300$ m.

The voltage across the primary winding N1 of the transformer 20 is rectified and smoothed by means of a diode D1 and a capacitor C2. If the secondary winding N2 of the transformer 20 is short-circuited as the result of remote tripping, then the voltage across the primary winding ~~N1~~N1 collapses, and the capacitor C2

is discharged via a resistor R6 connected in parallel with it. When the voltage across the capacitor C2 becomes less than the reference voltage U_{Ref} of the comparator 24, which is designed as an inverting comparator V2 with hysteresis, then its output changes from low level to high level. To this end, the comparator V2 is connected to the resistors R9, ~~R10~~R10 and to the capacitor C3 in the manner illustrated. The level change is used for controlling the actuation circuit 3 by the comparator V2 (24) supplying the appropriate control signal S_s via the comparator 13 to the base control input of the transistor 14. This results in the transistor 14 being switched on, so that current flows through the tripping relay coil 15 of the release 4, which is connected to the operating voltage U_b via the collector-emitter circuit of this transistor 14.

A resistor R5, which is connected downstream on the output side of the comparator VI of the square-wave oscillator 22 and is located in the primary winding N1 of the transformer 20, limits the current flow via the primary winding N1 when the secondary winding N2 is short-circuited in the situation where the power supply is live after remote tripping. In order to achieve a minimum current draw, R5 should be chosen to be $\geq 10 \text{ k}\Omega$.

The reference voltage U_{Ref} of the comparator V2 is produced by means of a reference voltage divider R7, R8, which is connected to a supply voltage U_v and contains a series-connected zener diode D2. As long as the rising operating voltage of the tripping circuit 5 is less than the response voltage of the zener diode D2 when the supply voltage U_v is connected, the reference voltage is $U_{Ref} = 0 \text{ V}$. When the supply voltage U_v is disconnected, the reference voltage U_{Ref} falls to 0 V when the falling operating voltage of the tripping ~~circuit 5~~circuits falls below the response voltage of the

zener diode D2. Spurious tripping caused by remote tripping electronics when the supply voltage U_v is being switched on and off is thus effectively prevented.

In an alternative method of operation of the DI circuit breaker, the secondary of the transformer 20 is short-circuited using a break contact as a remote tripping switch. Undershooting of the reference voltage U_{Ref} would then result in actuation of the release 4 owing to a change in the control signal S_s of the comparator 24 (V2) in the tripping circuit 5.

~~Patent Claims~~

Abstract

~~Protective switching device~~

ABSTRACT

~~In order to allow simple and reliable remote tripping in a~~
A protective switching device, in particular in a such as a
differential-current circuit breaker, having a core-balance
transformer (6) which monitors a line network (Ln) and which, via
a tripping circuit and an actuation circuit, actuates a release
~~(4) which is coupled to a switching mechanism (16) in order to~~
operate a power breaker (18), . The invention provides that a
tripping circuit (5) is provided having, which can be tripped by
means of a transformer (20) whose primary remote tripping signal,
is connected via an actuation circuit (3) to the release (4) and a
transformer which can be actuated on the secondary side and whose
primary side is connected to an actuation circuit of the release
~~for remote tripping, preferably by short-circuiting.~~

~~Figure 1~~

FIG 2

